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Cuckoo and Levy Flights Algorithm Applied to Unit-Commitment Problem

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ABSTRACT: As the power crisis is usual every year, it is important to make the generator operations optimal. Power production cost, generation cost, shutdown and start-up cost are considered in the formulation of unit commitment (UC), which makes it more important and it should be solved fast and effectively. The cuckoo via levy flights algorithm shortly called as cuckoo search algorithm (CSA) is applied to the unit commitment problem. This algorithm is compared with Shuffled frog leap algorithm (SFLA). Cuckoo search algorithm using IEEE ten generator system as test system and the performances are compared.

KEYWORDS: Cuckoo search algorithm, unit commitment, Shuffled frog leap algorithm, meta-heuristic search algorithm

I.INTRODUCTION

Unit Commitment problem [17] is a complex problem, which is the sum of total operating cost of generation, shutdown and start-up cost in the fitness function which is used to calculate the total operating cost of the unit commitment problem. This unit commitment problem can be solved by many optimization techniques [17], the research and development in intelligent methods and meta-heuristic methods make the improvement in the result of the unit commitment. Some of the literatures, which are solved by different methods, are described as follows.

The solution of the UC problem has two simultaneous solutions of two sub-problems, mixed-integer and non-linear programing problem [17]. For this problem, solutions are carried out using Priority list method (PL) [15], Dynamic programming method (DP) [26] [33], Lagrangian relaxation (LR) [5] [19] [21] [37] and meta-heuristic methods like Genetic algorithm (GA) [3] [8] [18] [28] [34] [39], Particle Swarm Optimization method (PSO) [5] [14] [27] [30] [38].

The PL method is fast but it is highly heuristic [17]. The DP method has mathematical complexity and increase in computation time (Ouyang. Z, 1992). LR method has its inherent sub-optimality. Javad Ebrahimi, has stated that the evolutionary algorithms like GA, PSO makes long execution time and non-guarantee the convergence to optimal solutions. And the Particle swarm optimization has large search space and its convergence is assured compared to GA. Shuffled Frog Leap algorithm (SFLA) based on solutions are better compared to PSO algorithm. The computation time and the production cost of the SFLA are less compared to LR, GA and BF [17].

Moosa Moghimi Hadji and other, has made the solution to the unit commitment using the imperialist competitive algorithm (ICA) based on the colonies populations. This algorithm is compared with the genetic algorithm (GA), integer coded genetic algorithm hybrid particle swarm optimization (ICGA), hybrid particle swarm optimization (HPSO) and bacterial foraging (BF). ICA gives a best solution over the reduction of cost function. Compared to the execution time BF is better compared to ICA. The results are also compared with 10, 20, 40, 60, 80 and 100-unit system and results are tabulated.

Xin-She Yang, has introduced a new meta-heuristic algorithm called cuckoo search via levy birds (CSA) for solving the optimization problems. The Cuckoo species has a behaviour called brood parasitic, which is combined with the Levy flights behaviour of fruit flies. This algorithm is more generic and robust for many optimization problems. Cuckoo search algorithm is applied to the non-convex economic dispatch problem in power system [7]. The algorithm solves the economic dispatch problem with less cost value compared to other algorithms stated in this section.

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In this paper Cuckoo search algorithm is applied to the unit commitment problem.

II. UNIT COMMITMENT PROBLEM FORMULATION

The unit commitment problem is formulated using the generator fuel cost function, start-up cost and shutdown cost [1]. Start-up cost is modelled as two-valued staircase function [18]. The stepwise formulation is given below. [16]

(i) Minimum Up time and down time constraints:

$$\begin{cases} T_i^c \geq MU_i \ if \ T_i^c \geq 0 \\ -T_i^c \geq MU_i, if \ T_i^c > 0 \end{cases} \quad (1)$$

Where T_i^c is a sign integer that represents the continuous ON/OFF Status during *cth* cycle of unit *i.* then

$$\sum_{c=1}^{c} |T_i^c| = T \quad (2)$$

(ii) The upper and lower limits of *ith* generation unit, as follows:

$$P_{i\,min}^t < P_i^t < P_{i\,max}^t \quad (3)$$

(iii) The ramp and down rates:

$$P_{i\,max}^t = \min\{P_{i\,max}, P_i^{t-1} + \tau . RU_i\} \quad (4)$$

$$P_{i\,min}^t = \max\{P_{i\,min}, P_i^{t-1} - \tau . RU_i\} \quad (5)$$

here τ is equal to 60 min and it is UC time step.

(iv) Power balancing of the Power system is presented by

$$\sum_{i=1}^{N} u_i(t) . P_i^t = D^t \ ; \quad t = 1, \ldots T \quad (6)$$

(v) The Spinning reserve (10-min) of the power system:

$$\sum_{i=1}^{N} u_i(t) . P_{i\,\max r}^t \geq D^t + R^t; \quad t = 1, \ldots T \quad (7)$$

where $P^t_{i\,max\,r}$ is 10-min maximum response rate constrained power generation of *ith* unit, and is defined by (iii) with τ =10.

III. CUCKOO SEARCH VIA LEVY FLIGHTS

Cuckoo Birds that are found in Europe, Asia and Africa (winter season) has many interesting features in breeding. The birds like *Ani* and *Guira*, lays eggs in communal nest. Apart from its sweet sound it makes some mimicry. Usually it chooses a host nest to lay eggs. The cuckoo eggs look alike the host birds' egg. Generally cuckoo eggs hatches fast compared to the host eggs. After that the host bird make a move from the nest and build a new nest there it lays eggs. Or it randomly pushes the eggs from the nest. So how much number of cuckoo birds survives in the host nest is the best nest for the parent cuckoo. The Cuckoo chicks also make the mimicry like the host chicks to get the maximum food from the host bird. By making this as a mathematical concept, the algorithm is build for solving the optimization problem with the help of Levy flights. It is used in the random walk of a variable for choosing the random nests.

Some assumptions are made to make the algorithm simple. [37]

1) Each Cuckoo lays one egg at a time and dump it in random chosen nests
2) The best nests with high quality of eggs will carry over to the next generation.
3) The number of available host nests is fixed and the host bird discovers the egg laid by a cuckoo with a probability between 0 and 1.

Here each egg in a nest represents a solution and a cuckoo egg represents a new solution.

Cuckoo birds via levy flights algorithm is shortly called as cuckoo search algorithm (CSA) has proven that it gives better results compared to PSO and GA, which are meta-heuristic optimization algorithms. Comparison is done with certain number of run and success rates are better compared to PSO and GA.

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IV. UNIT COMMITMENT USING CSA

In Cuckoo search initial population is done with the nests, here the nest are the initial population. The population is taken for the continuous unit-operating hour. With the initial population the fitness function is evaluated. After making the randomization, minimum up and down time constraints are automatically satisfied [17]. Fitness function is the summation of total fuel cost, start-up and shut down cost. Get a cuckoo from levy flights randomly and calculate its fitness. If the calculated fitness (F_i) is less than the next random nest fitness (F_j) then replace F_j with F_i , else keep the same nest. Now worst nest is abandoned and next random nest is formed. Keep the best nests and rank them and find the best one which is optimum. Do the operation until the termination criteria are satisfied. Finally print the best results. Figure 2 indicates the operation as flowchart.

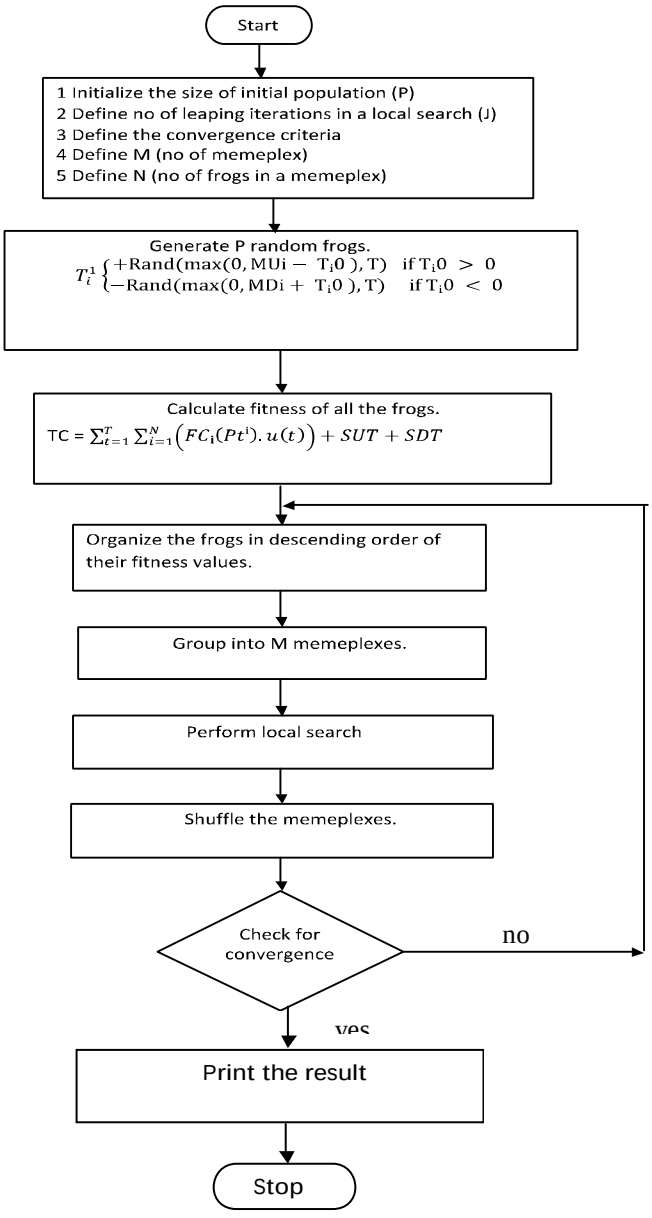

Fig.1 Flow chart of UC using SFLA

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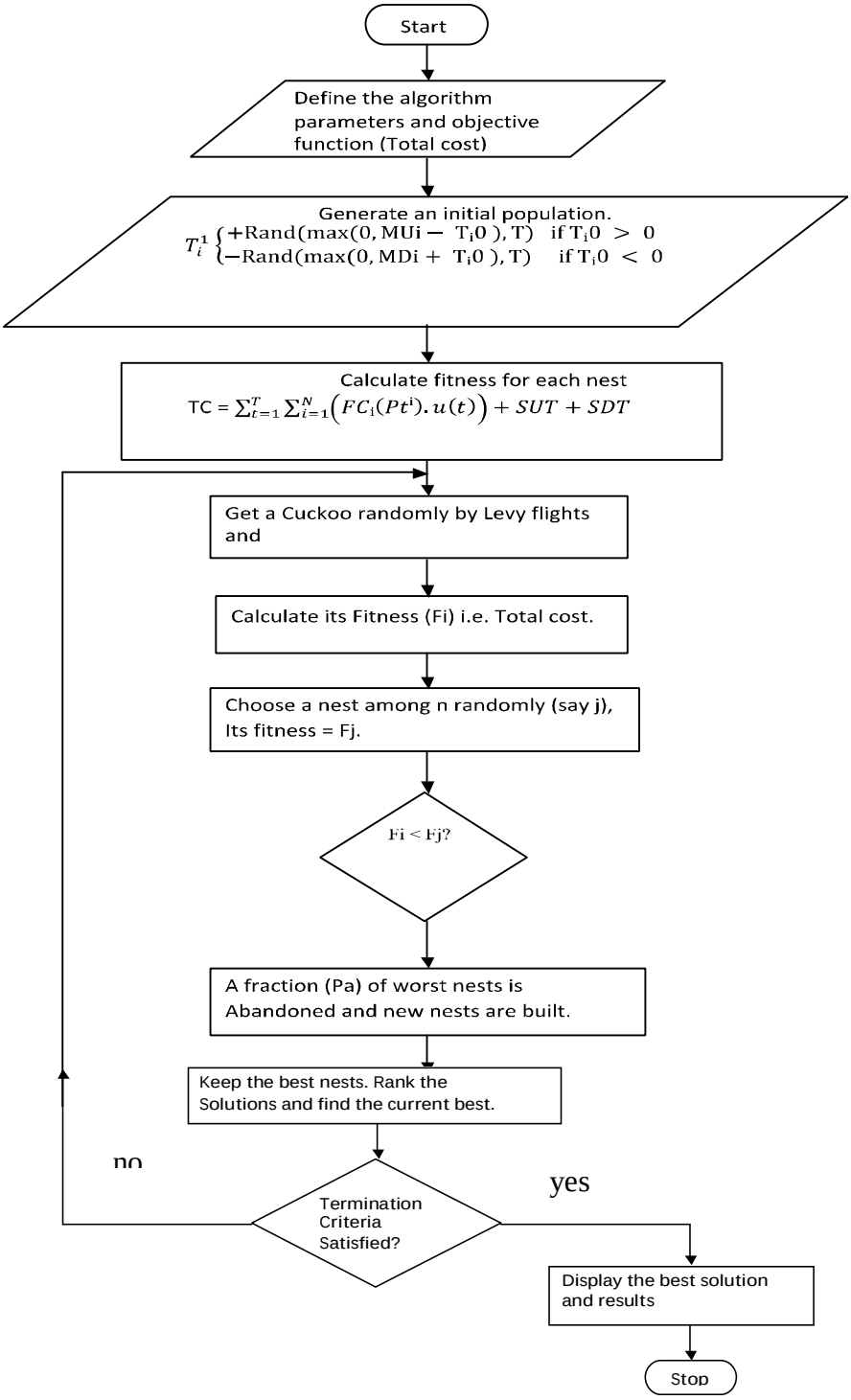

Fig.2 UC solution using CSA

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V. RESULTS AND DISCUSSION

The results of the SFLA algorithm and CSA algorithm are compared here. As the Cuckoo search serves better on UC compared to SFLA. The parameters of the comparison are given in the table 1.

TABLE I
Comparison of SFLA and CSA for Unit-Commitment Problem

S.no	Performance Comparison	
	SFLA	CSA
1	Execution time is more to obtain the same results as compared to CSA	Execution time is less Compared to SFLA
2	Number of iterations required to obtain the same result as that of CSA is more (Total cost reaches up to 576000 in 3000 (30*100) iterations	Less number of iterations are required. (Total cost decreases up to 575000 in 2300 iterations)
3	More Number of population size is required	Less number of population size is required
4	Slow convergence	Fast convergence
5	Search area is less	Search area is more

So from the table we can see that the cuckoo search algorithm gives execution time less, it converges with in less iteration number, less number of population size, more search ability and fast convergence compared to the SFLA algorithm.

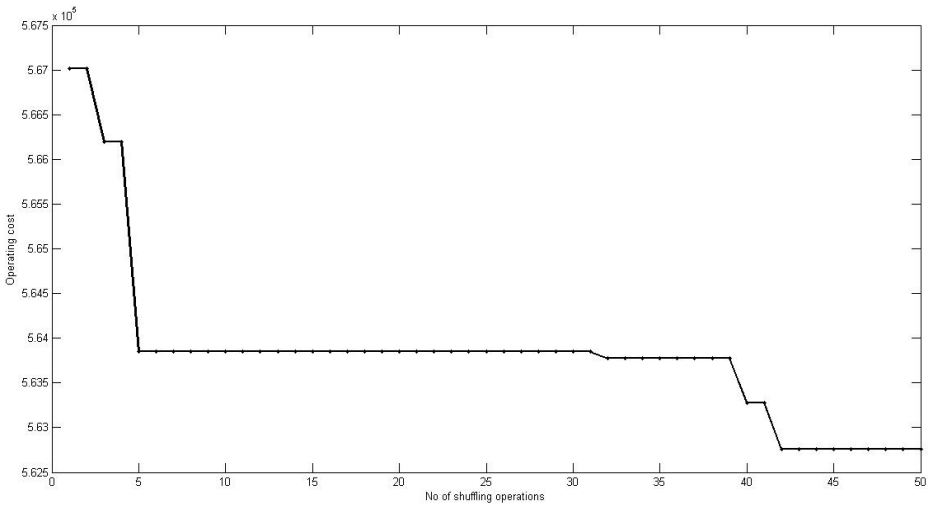

Fig. 3. Cost function Vs No. of shuffling operations (SFLA)

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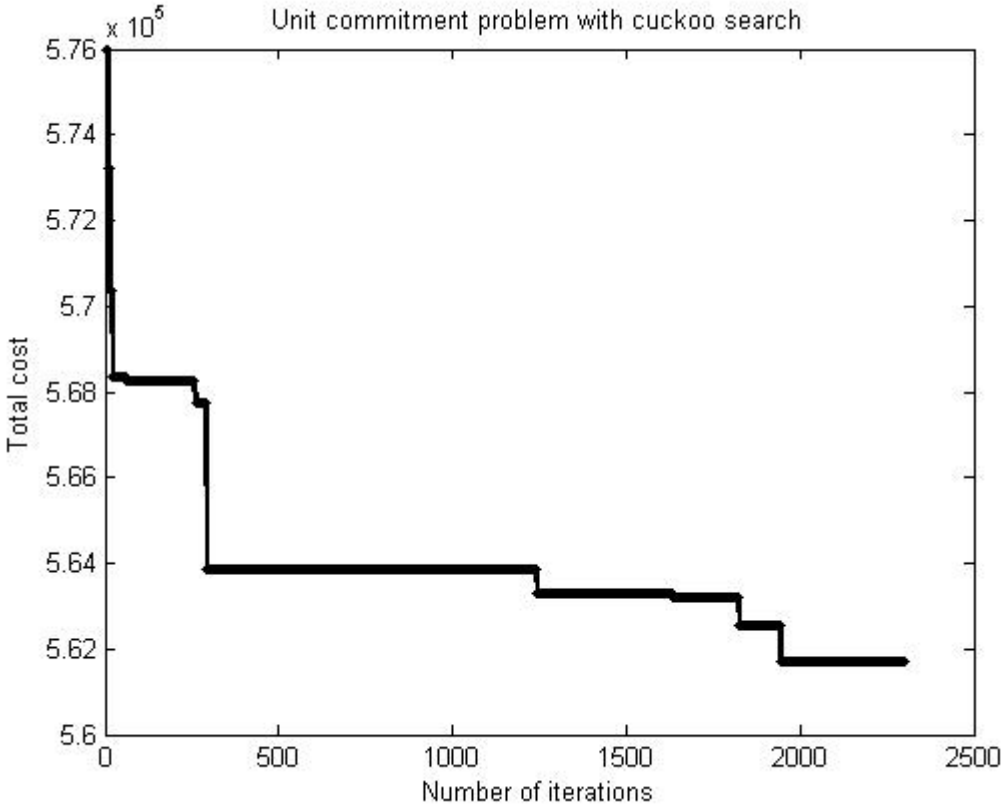

Fig. 4. Cost Function Vs Number of iteration (CSA)

From the Figure 3 the Shuffled frog leap algorithm gives the results on the number of shuffling operation that means here 50 iterations multiplied by 1000, so totally 50000 thousand iterations are carried out. But Using CSA, 2300 iterations are used to get the solution. The cost function also reduced compared to SFLA.

VI. CONCLUSION

The Cuckoo search algorithm solves better compared to shuffled frog leap algorithm. The results and discussion show the graph and the tabular column of the comparison. SFLA takes more number of iterations compared to CSA and the total fuel cost values also reduced using cuckoo search. And also the Cuckoo search algorithm gives 100% success rate in 10,000 number of run. Were in SFLA it is 97%. So the CSA serves better compared to SFLA.

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